Redesigning Teaching Approaches for Undergraduate Engineering Classrooms

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ABSTRACT

Our research focuses on the redesign of an undergraduate engineering course to implement effective pedagogies of engagement. Inquiry-based learning, coupled with hands-on team projects which simulate real-world problem-based scenarios, promotes the transfer of knowledge for practical problem solving in authentic engineering design problems.

DEFINITIONS

The American Engineering Council defines engineering as:

- The creative application of scientific and mathematical principles to practical ends such as design or develop structures, machines, process, designs …. to forecast their behavior under specific operating conditions ….

Problem-Based Learning (PBL) focuses on:

- An understanding of the problem instead of the solutions. Learning results from the process of working toward an understanding or resolution of the problem.

Constructivist Perspectives of Learning support:

- Collaborative learning in which students are asked to apply knowledge and "construct" solutions, using inquiry, critical thinking, and openness to multiple perspectives (Driscoll, 2005; Wolfolk, 2010).

ENHANCING MOTIVATION

- Pedagogical methods that work with students from non-engineering disciplines vary for students within engineering fields.
- Pedagogies of engagement, such as discussion, debates, and student opinions are easily implemented in courses in the Arts and Humanities but are rarely implemented in Engineering Education courses.
- Undergraduate engineering students usually lose their interest, due to the demanding mathematics within the engineering courses.
- PBL in engineering courses helps students develop critical thinking. For example, formulating a problem is the first step towards solving a problem, but many students in engineering courses have not experienced this approach.

TRADITIONAL ENGINEERING EDUCATION APPROACHES

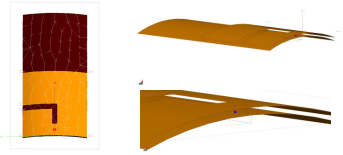
- Engineers work with rules and laws. Engineering faculty teach basic science and the fundamentals, such as the properties of material, along with rules and limitations.
- Lab courses promote active and problem-based learning.
- Teacher-oriented lectures and blackboards are still commonly used in many engineering classrooms.
- "Trust me" approach: "*trust me*, you need to know this to be successful in your field" (Felder, 2000).
- Lab courses usually have manuals to assist students. Lab manuals, with step-by-step instructions on how to conduct an experiment, hinder students' creative thinking.
- Note: Many electrical and computer engineering courses, such as microwave and antenna design, cannot be taught with mathematical derivation in details.

IMPLEMENTATION OF EXPERIMENT-BASED PEDAGOGIES

- Cooperative learning (working together to solve a problem) and problem-based learning are often introduced for the first time in the senior design project, when students are tested on their ability to solve complex engineering problems.
- Students are given opportunities to practice what they learn and as they learn and use their education in practice.
- The measure of success includes knowledge acquisition, retention, problem formulation, thinking with reasoning and problem solving.
- We have developed hands-on experiments that can be integrated in mathematics extensive courses, such as Microwave and Antenna design.

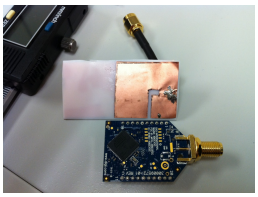
METHODOLOGY

- We propose introducing real world engineering designs and technology in classrooms where students are learning the basics of science and engineering.
- Students will work together to understand well-defined projects and further develop possible solutions. Though step-by-step instructions are not provided, students are guided whenever needed.
- Well defined designed parameters and limitations:



Design of Dual Band Antenna

- Real-life design problems:



Dual Band Antenna & Sensor Node

Kit and Material for the Experiments

CONCLUSIONS

- Real life engineering examples should be implemented in engineering classrooms.
- The Design Project should stimulate, challenge, and empower students.
- Lab courses should be designed to promote active and problem-based learning.

Note: This research is sponsored in part through the Title III grant at the University of Bridgeport, which is supported through the United States Department of Education.

Dr. Hassan Bajwa is the 2011-2012 Scholar-in-Residence at the Center for Excellence in Learning and Teaching at the University of Bridgeport, Bridgeport, CT.

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